UNPUBLISHED
SURVEY & CONTROL
REPORTS

INTERMOUNTAIN STATION
Central Reference File
No. 3.416.1

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

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FIELD MANUAL OF BARKBEETLE SURVEY METHODS

CALIFORNIA REGION

by

Philip C. Johnson
Junior Forester

U.S. Bureau of Entomology and Plant Quarantine

Berkeley, California
May 1, 1935
(Revised May 1, 1936)

U. S. GOVERNMENT PRINTING OFFICE: 1936 J 76133

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LABORATORY

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BARKBEETLE SURVEY METHODS

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FIELD FORMS

Tree record
Spotting record
Plot Maps - Blueprints
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Plot Data - Regional Survey
Stem analysis record
Photographic record

CORRECTION FACTORS FOR COMPASS ALIGNMENT

Error	Correction
0.25 ch	0° 11'
0.50	0 21
0.75	0 33
1.00	0 43
1.25	0 54
1.50	1 04
1.75	1 15
2.00	1 26
2.25	1 37
2.50	1 47
2.75	1 58
3.00	2 09

Corrections are in degrees and minutes of angle for errors in chains, and apply to lines one mile in length. Double the correction for lines one-half mile in length.

If the random line falls to the right of the true line, the correction is to be added to the magnetic declination; if to the left, subtract the correction (where the magnetic declination is east).

LOCATION OF METAL TAGS ON REGIONAL SURVEY PLOTS

Metal tags are placed along the boundary and intermediate cruise lines parallel to the longitudinal axis of the plot. In addition, each line is brushed out where needed. The advantage of this type of plot marking is found in the increased speed of cruising because of the fact that no compass or pacing work is necessary, the plot boundaries being definitely established and permanently marked. The spotters can easily determine the width of the strip in most cases much more closely than ocular determinations.

Two types of tags are used; boundary and cruise tags. Boundary tags are stamped with the regional survey plot number and the identifying "Bureau of Entomology" imprint. The cruise tags are stamped with the coordinate distance and direction from the southwest corner of the plot. A tag which reads $\frac{15E}{22.5N}$ means that particular tag is 15 chains east and 22.5 chains north of the southwest (zero) corner of the plot.

Tags are placed only by compass and chaining and are usually on the nearest tree along the compass line. A certain variation, either one chain forward or to the rear of the chain point, is allowed, and not more than one-half chain off the compass line in either direction. Boundary tags are etched with the distance in paces from the chain point.

Boundary tags are placed every five chains along the four sides of the plot as shown in the accompanying chart. Cruise tags are placed every 2½ chains along the boundary and intermediate cruise lines as shown. The direction toward which the tags face is determined by the initial point of the cruise and also by the direction of the plot axis. The bark should first be smoothed with an axe or hand-axe before nailing the tag. This exposes the fresh inner bark and eliminates the outer loose bark scales. Nails should

never be driven to the head, especially in oaks and young trees whose diameter growth soon forces the tags off. Plots should receive maintenance work at least once every five years to replace missing tags and brush out boundary and cruise lines.

FOREST TYPES

The forest types to be used in mapping new plots or the correction of existing maps corresponds to those used by the California Forest and Range Experiment Station and now recognized as standard by all other branches of the U. S. Forest Service Region 5.

Four vegetation formations are usually noted in the regional survey: herb type, shrub type, woodland tree type, and commercial tree type.

Herb types include those in which the dominant ground cover is 80 percent or more herbaceous (grasslands, meadows, etc.)

Shrub types are those in which 80 percent or more of the ground cover is dominated by shrub growth. Three shrub types are recognized:

(a) Sagebrush type; 80 percent or more of the ground cover dominated by Salvia. (Thistle-sage), Artemesia (Sagebrush), Eriogonum (wild buchwheat), or Purshia (Bitterbrush, Antelope brush).

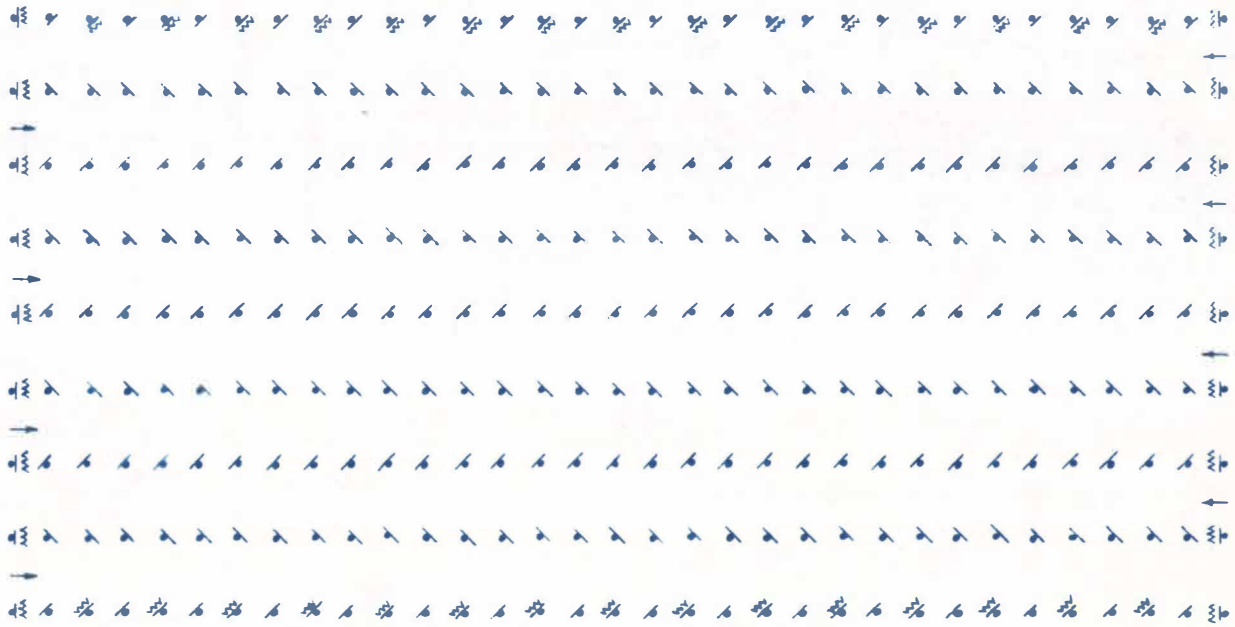
(b) Chaparral type; 80 percent or more of the ground cover consisting of shrubs not sage-like in their characteristics, as, for example, shrubby Quercus (Oak), Arctostaphylos (Manzanita), and Ceanothus

(c) Chaparral-sagebrush type; both chaparral and sagebrush species are dominant but neither forms 80 percent of the ground cover.

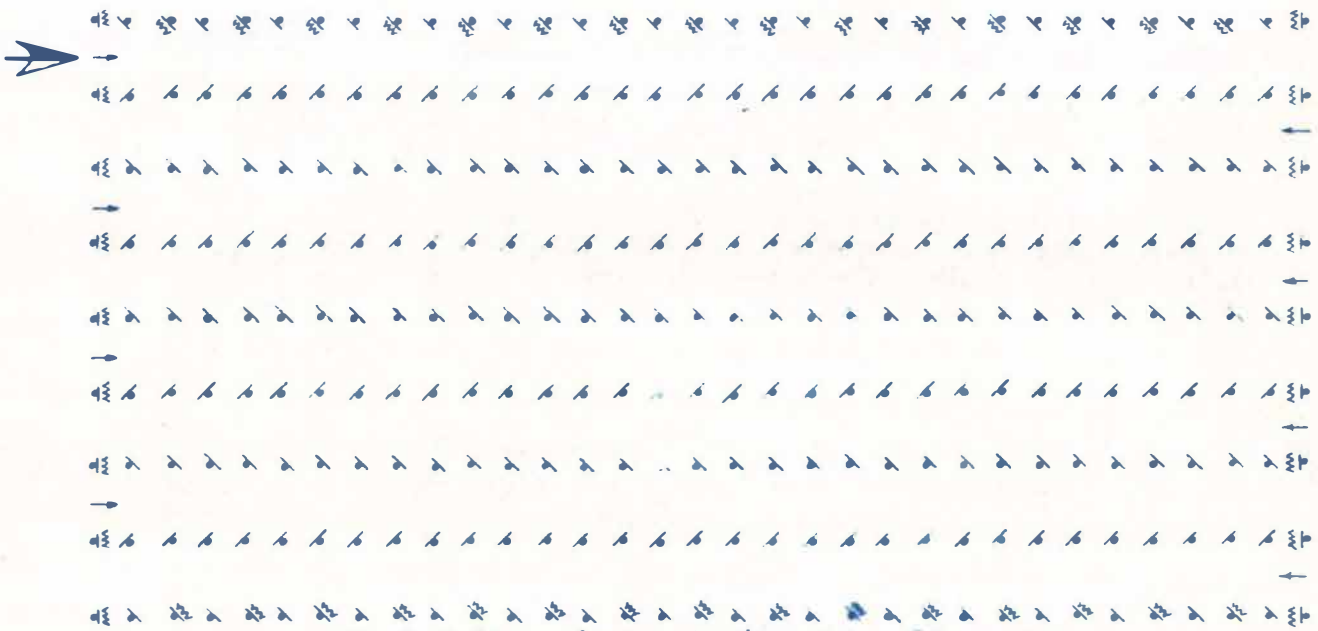
Tree types are those in which 80 percent of the ground cover is dominated by broadleaf, broadleaf-conifer, or conifer types. Woodland tree types are characterized by either broadleaf or conifer species whose wood is little used except for fuel. This includes Digger, Coulter, Monterey, Pinon, Knobcone pine, juniper, oak, etc. Commercial tree types are designated because they are characterized by those conifers considered commercially valuable in California for such products as lumber and pulpwood. These include ponderosa, Jeffrey, sugar pines, redwood, Douglas fir, white fir, etc.

A pure tree type is one in which 80 percent or more of the ground cover is made up of one tree species. A mixed tree type contains more than one dominant tree species, no single species being present to the extent of 80 percent of the ground cover. Any species (tree, shrub or herb) dominating the ground cover to the extent of 20 percent shall be included in the type designation.

LOCATION AND DIRECTION
OF
REGIONAL SURVEY PLOT TAGS



For E-W Plots. Cruise starting SW or NE corner
For N-S Plots. Cruise starting NW or SE corner



For E-W Plots. Cruise starting NW or SE corner
For N-S Plots. Cruise starting SW or NE corner

LEGEND

- Start of Cruise
- Cruise Direction
- Tree or Stake
- Cruise Tag
- Boundary Tag

The symbols of the more common types to be found in the commercial pine belt of California are shown below:

Barren		Trees	
Ba	Barren		
Shrubs		$\hat{W}$	Abies concolor (White fir)
Af	Adenostoma fasciculatum (Chamise)	$\hat{R}$	Abies magnifica (Red fir)
Ap	Arctostaphylos patula (Greenleaf manzanita)	J_U	Juniperus californica utahensis (Utah juniper)
At	Arctostaphylos tomentosa (Wooly manzanita)	J_o	Juniperus occidentalis (Western juniper)
Atr	Artemesia tridentata (Common Sagebrush)	L	Pinus contorta (Lodgepole pine)
Cs	Castanopsis sempervirens (Sierra chinquapin)	C_P	Pinus coulteri (Coulter pine)
Cco	Ceanothus cordulatus (Mtn. whitethorn)	S	Pinus lambertiana (Sugar pine)
Cc	Ceanothus cuneatus (Wedgeleaf soapbloom)	Y	Pinus ponderosa (Ponderosa pine)
Ci	Ceanothus intergerrimus (Sweetbirch soapbloom)	J	Pinus jeffreyi (Jeffrey pine)
Cpo	Ceanothus prostratus (Squaw carpet)	D_P	Pinus sabiniana (Digger pine)
Cv	Ceanothus velutinus (Snowbrush)	A	Populus tremuloides (Aspen)
Cb	Cercocarpus betuloides (Birchleaf mtn. mahogany)	B_S	Pseudotsuga macrocarpa (Bigcone spruce)
Cl	Cercocarpus ledifolius (Curlleaf mtn. mahogany)	D	Pseudotsuga taxifolia (Douglas fir)
Cf	Chamaebatia foliolosa (Bearclover)	C	Quercus chrysolepsis (Canyon live oak)
Pd	Prunus demissa (Western chokecherry)	B	Quercus kelloggii (California black oak)
Pe	Prunus emarginata (Bittercherry)		
Pt	Purshia tridentata (Bitterbrush, Antelope brush)		
Sx	Salix spp. (Willow)		

SITE INDEX

Using the total height of the dominant mature trees, the following site classes will be used:

Site I	175' and over
Site II	150' to 175'
Site III	125' to 150'
Site IV	100' to 125'
Site V	75' to 100'

VOLUME TABLES

Ponderosa pine .....General Volume Tables, Site I-V inclusive, U.S. Forest Service, 1927.
Jeffrey pine .....Use above ponderosa pine volume tables.
Sugar pine .....Table #33 and #34, Site I and II, "Volume Tables for the Important Timber Trees of the U.S." by Munns and Brown, 1925.
Incense cedar.....Table #91, "Volume Tables for the Important Timber Trees of the U. S." By Munns and Brown, 1925.
White fir.....Table #69, 70, and 71, Site I, II, and III. "Volume Tables for the Important Timber Trees of the U. S." By Munns and Brown, 1925.

TREE CLASSES

Dunning's* Tree Classes

Tree Class	Age Class	Crown Position	Crown Length	Crown Width	Crown Shape	Vigor	Size of Tree
I	Y-TM	X-D (C)	65%+	M-W	Pointed	V	Up to 30" DBH
II	Y-TM	C (X-D)	65%-	M-N	Pointed	V-M	Up to 24" DBH
III	M	X-D (C)	65%+	M-W	Round	M	Usually 18-40"DBH
IV	M	C (X-D)	65%-	M-N	Round	M-P	Usually 18-40"DBH
V	OM	X-D (C)	All	All	Flat	P	Largest
VI	Y-TM	I-S	All	All	Round Pointed	M-P	14" DBH or less
VII	M-OM	I-S	All	All	Flat	P	18" DBH or less

SYMBOLS:

Age class: Y-TM, young or thrifty mature; M. mature; OM, overmature.
Crown class: X, isolated; D, dominant; C, codominant; I, intermediate; S, suppressed.
Crown width: M, average; W, wider than average; N, narrower than average: ALL, any size.
Vigor: V, good; M, moderate; P, poor.
Size: Sizes given are approximate though some variation may occur.

* Dunning, Duncan, "A Tree Classification for the Selection Forests of the Sierra Nevada", Jour. Ag. Res. Vol.36, No.9, 1928.

Keen's Tree Classes

Based upon Dunning's tree classes. Groups 1, 2, 3 and 4 based upon age shown by size of tree, shape of top, and bark; classes a, b, c, and d are concerned with growth and thriftiness, as evidenced by size of crown, degree of dominance, and general character of foliage. A tree class designation is composed of the combination of a number and letter, viz., 1a, 4c, 3d, etc. Sixteen classes are recognized. The component

A Tree Classification For the Selection Forests of the Sierra Nevada

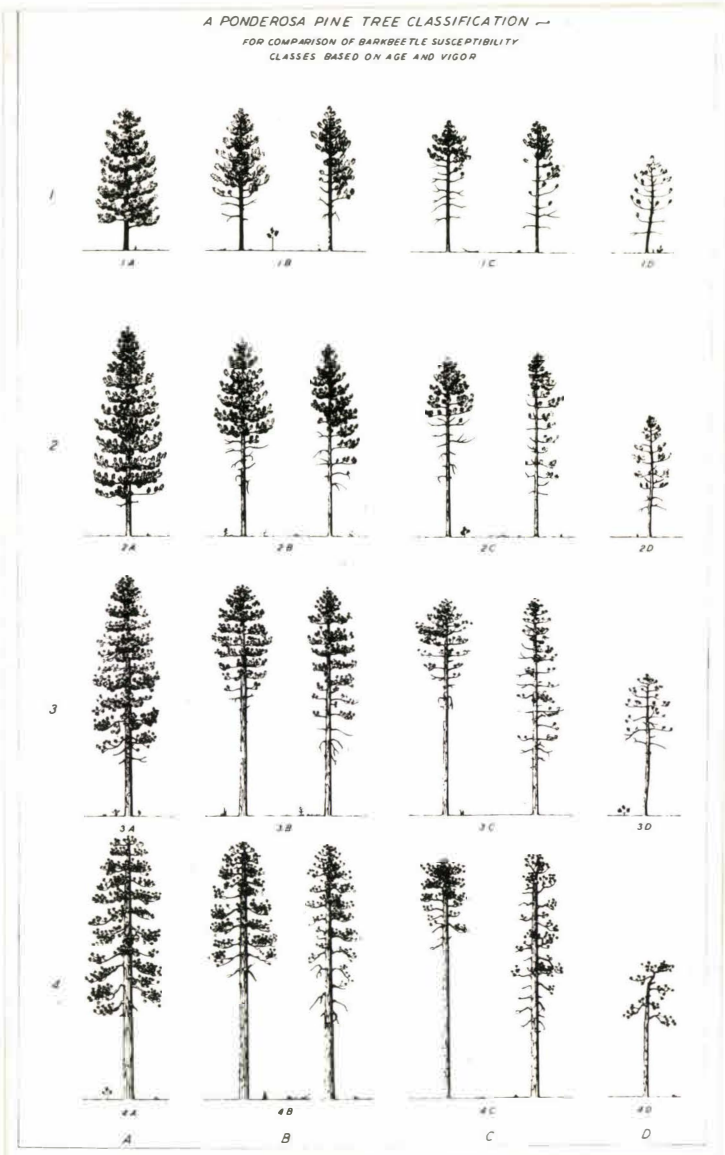
by
Duncan Dunning

TREE CLASSES - SELECTION STANDS -WESTERN YELLOW PINE

A Tree Susceptibility Classification

by

F. P. Keen



parts of the classification are as follows:

1. 75 yrs. or less; blackjack type, pointed top; bark black, smooth.
2. 75-150 yrs.; immature; bark black with small ridges and crevices.
3. 150-300 yrs.; mature; bark with large yellowish ridges.
4. 300 yrs. and over; decadent; bark with large yellow plates.

a. Crown length, 65% or over; top pointed; thriftiness, good.
b. Crown length, less than 65%; thriftiness, good.
c. Crown length, intermediate; thriftiness, fair.
d. Crown length, all sizes; thriftiness, poor.

A comparison of Dunning's and Keen's tree classes is shown below:

Dunning	Keen
1	1a, 2a
2	1b, 1c, 2b, 2c
3	3a
4	3b, 3c
5	4a, 4b, 4c
6	1d, 2d
7	3d, 4d

CORRECTION FACTORS FOR ESTIMATING SEASONAL LOSSES

Insect losses obtained from the regional survey represent only a fraction of the total seasonal loss. Surveys made from May to December of any one year would show only a portion of the total loss for that year due to the fact that external signs of infested trees often do not appear until after the cruise has been made and many attacks are not made until late in the fall following some of the cruises. Naturally, as the season progresses from early summer until late fall an increasing percentage of the total loss would be obtained from the survey or individual cruises. A correction factor must then be applied to the cruised losses to obtain the total seasonal loss. The basis for the correction factor is the accompanying curves which show the average percent of total infestation cruised on certain dates for areas representing different environmental conditions.

The percentage figure obtained from the curve must be tempered to allow for current variations such as (1) the trend of the infestation, (2) the composition of the infestation, (3) the composition of the stand, (4) climatic conditions, (5) elevation, and (6(variation in spotting.

As an example, the cruise made on a certain plot on the Lassen National Forest on September 20, showed a loss of 30 ponderosa pine trees, with a volume of 30,000 board feet. From the correction curve of the Lassen National Forest, we find that on September 20, the factor for ponderosa pine is 55 percent. Using this figure as a starting point, the estimator allows for the above mentioned variables. The actual

percentage figure to allow for each or several variables is difficult and depends to a large extent upon the experience and judgment of the estimator. Certain effects have been shown graphically and are based upon the average occurrence of that variable over a number of years. The above figure (55 percent) sometimes need not be changed if the environment conditions are normal. The effect of each of the variables will be discussed briefly to show the approximate importance of each, so that if the basic factor (55 percent) need be changed some idea of the direction and amount of change will be available.

Trend of Infestation. In increasing infestations the figure obtained from the curve (55 percent) is to be lowered; probably from 5 to 10 percent for slightly increasing infestations and as much as 25 percent or more for rapidly increasing infestations. The opposite correction is made for decreasing infestation. This factor will be negligible for infestations of a somewhat stable character.

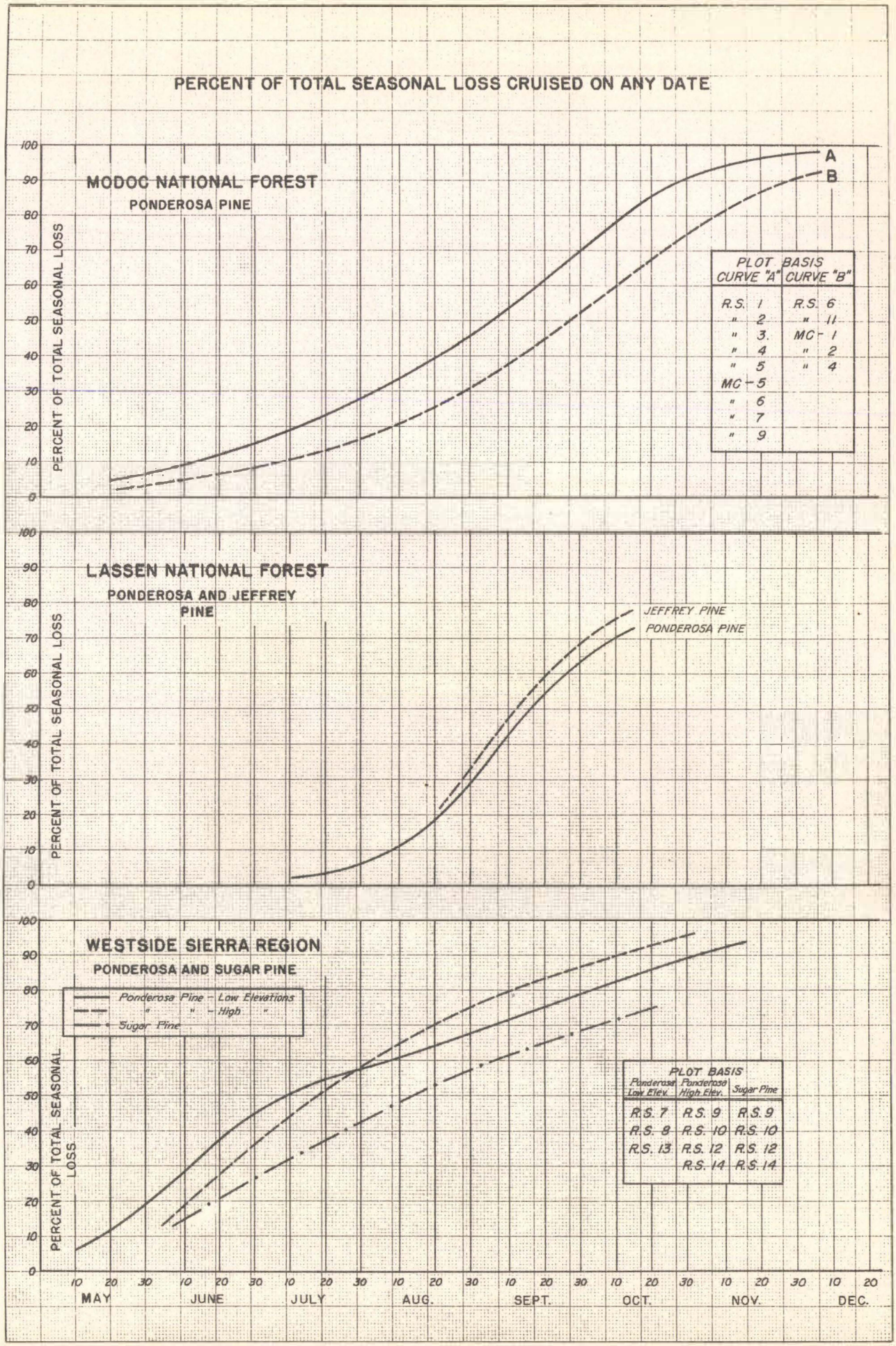
Composition of Infestation. The only relationship existing at present shows the difference of the rate of attack in ponderosa pine of the western pine beetle and flathead borers of the genus Melanophila. Since the attacks of the flathead borers are slower to appear, an increase in the abundance of "flathead" trees would tend to lower the basic factor (55 percent) obtained from the curve.

Composition of the Stand. This variable and its effect is shown graphically. Little or no correction need be made in Jeffrey pine stands on the eastern Lassen and eastern Plumas national forests since the rate of the appearance of attacks is nearly equal that of ponderosa pine in normal seasons. In the westside Sierra region, however, attacks in sugar pine occur at a different rate than those in ponderosa pine at the same elevation. Those plots having a large percentage of sugar pine making up the stand will usually cruise a lower percentage of total seasonal loss than will pure ponderosa pine plots under similar conditions and on the same date.

Climatic conditions. Early springs will usually result in earlier insect activity which may raise the percentage of total seasonal loss cruised during the early summer. The early advent of cold weather in the fall would have a tendency to increase the percentage of total seasonal loss cruised during the late summer and early autumn months.

Elevation. This factor should be taken into consideration when estimating total seasonal losses on large units based upon several sample plots differing considerably in elevation. The rate of appearance of attacks in ponderosa pine at different elevations in the westside Sierra region is shown graphically in the accompanying chart. No correction for elevation is necessary on eastside plots because of the uniform topography.

PERCENT OF TOTAL SEASONAL LOSS CRUISED ON ANY DATE



Variation in Spotting. This item is a potential source of error in estimating seasonal losses from cruised losses obtained in the regional survey. Careful training and supervision of new men and the due consideration of all phases of spotting work by field crews will eliminate much of this error.

INFESTATION TYPES

A recent study by the Bureau based upon the stem analyses of 782 infested trees on east and westside plots has shown a wide variation in the manner in which trees are attacked. There were approximately 60 combinations of attack ranging from pure attacks by one species to those in which several species occurred at varying points along the bole or stem. Out of this number there appeared to be four rather common and important infestation types:

1. Western pine beetle
2. Western pine beetle - flathead borer
3. Western pine beetle - engraver beetle
4. Western pine beetle - mountain pine beetle - flathead borer

Pure and complete attacks by the western pine beetle (Dendroctonus brevicomis Lec.) are common on eastside plots and uncommon on the west side of the Sierras. A slight modification of this type, in which the attacks do not extend to the 4" top diameter limit, are common on both the east and westside plots. This same type with green basal areas appears to some extent on the westside and seldom on the eastside.

The second type, western pine beetle - flathead borer (Melanophila spp.) is the most common on the eastside plots and fourth in importance on westside plots. The combination of the two species may extend from the base to the top of a tree, or may exist with pure flathead infestation in the top and pure western pine beetle in the base.

The western pine beetle - engraver beetle (Ips spp.) type was of considerable importance on the westside plots due to a large extent to the outbreak of engraver beetles in that area during the study. Its occurrence on the eastside is of minor importance. It was shown that attacks on the lower and middle bole by the western pine beetle followed those of engraver beetles in the top portion of the bole. This same type with a green base was very common on the westside.

The type containing a mixture of western pine beetle, mountain pine beetle, (Dendroctonus monticolae Hopk.) and flathead borers occurs predominately on the eastside plots. Broods of one or two of the species may occur in all the infested bark on a tree. Usually the three species occur together only in the middle region with the western pine beetle extending to the base and the flathead borers to the top of the tree.

The one feature which was clearly emphasized was the probability of determining the presence of the species in the middle and upper bole regions solely from the basal examinations made by the spotter. For instance, a green base in an infested tree might have 13 combinations

of attacks above the reach of the spotter, none of which would be discernible to the spotter. Since the spotting work must be done almost wholly by basal examination, the qualitative data secured by the regional survey is not an accurate picture of the pine beetle infestations throughout the State. Detailed information regarding the various insect species making up the infestation must still be obtained from stem analyses made during control operations when a large number of infested trees can be examined with the minimum of time and labor.

LOCATION OF SAMPLE PLOTS

The sample plots now covered by the regional survey are listed on the following pages. It will be noted that there are three series, the regional survey plots, ordinary survey plots, and cutover plots. All plots bear a number, each of the three series having its own system of numbers.

Regional survey plot numbers are preceded by "R. S.", the numbers beginning with "one" and progressing in consecutive order regardless of their location.

Survey plots, not marked permanently as are the regional survey plots, are numbered consecutively on each national forest or park. The number consists of the abbreviation of the national forest and the serial number beginning with "one" on each forest. The abbreviations of the national forests in Region 5 (California) of the U.S. Forest Service are as follows:

A	Angeles	P	Plumas
CL	Cleveland	SA	Santa Barbara
E	Eldorado	SE	Sequoia
I	Inyo	SH	Shasta
K	Klamath	SI	Sierra
L	Lassen	SO	San Bernardino
M	Mendocino	SS	Stanislaus
MC	Modoc	TA	Tahoe
MO	Mono	TR	Trinity

Cutover plot numbers are preceded by "CO", the numbers beginning with "one" and progressing in consecutive order regardless of their location.

LOCATION OF PLOTS

Nat. Forest	Plot	Acres	Subdiv.	Section	Twnsp.	Range	Meridian	Cruise Dir.	Site
Modoc	R.S.1	320	S½	22	43 N	7E	Mt.D	E-W	III
	R.S 2	320	E½	18	41 N	6E	"	N-S	III
	R.S 3	320	W½	28	42 N	7E	"	N-S	III
	R.S.4	320	N½	36	44 N	5E	"	E-W	V
	R.S 5	320	W½	16	44N	8E	"	N-S	IV
	R.S 6	320	N½	19	41 N	5E	"	E-W	III
	RS 11	320	In part	5-8	46 N	15E	"	N-S	III
	MC-1	320	N½	4	41 N	8E	"	E-W	III
	MC 2	320	N½	27	43 N	7E	"	E-W	III
	MC 3	320	N½	12	43 N	6E	"	E-W	IV
	MC 4	320	N½	26	44 N	7E	"	E-W	IV
	MC 5	320	W½	10	43 N	8E	"	N-S	III
	MC 6	320	N½	35	44 N	8E	"	E-W	IV
	MC 7	320	S½	13	44 N	8E	"	E-W	IV
	MC 8	320	W½	15	42 N	6E	"	N-S	III
	MC 10	320	W½	24	41 N	4E	"	N-S	III
	CO-5	320	E½	20	43 N	5E	"	N-S	IV
Shasta	SH-1	320	E½	14	38 N	3E	"	N-S	III
			W.boundary of plot 10 chs. W. of N-S center line of Sec. 14. E.boundary of plot 10 chs. W. of E. line of Sec. 14.						
	SH 2	320	W½ SW¼	34	39N	3E	Mt. D	N-S	II
			E½ SE¼	33	39N	3E	"		
			E½ NE¼	4	38N	3E	"		
			W½ NW¼	3	38N	3E	"		
	SH 3	320	S½ SW¼	12	37N	3E	"	N-S	IV
			NW¼	13					
			N½ SW¼	13					
	SH 4	320	S½ SW¼	6	37N	3E	"	N-S	III
			S½ SE¼	6					
			N½ NW¼	7					
			N½ NE¼	7					
	SH 8	320	E½	28	36N	3E	"	N-S	III
	SH 9	320	E½	33	39N	4E	"	N-S	III
	CO-1	160	SESE, SWSE SESW, SWSW	34	45N	2E	"	E-W	V
	CO 2	120	NWNW, SWNW NWSW	32	44N	1E	"	N-S	IV
	CO 3	160	In Part	29-32	44N	1E	"	N-S	IV
	CO 4	640		28	43N	3W	"		V

Nat.Forest	Plot	Acres	Subdiv.	Section	Twnsp.	Range	Meridian	Cruise Dir.	Site
Lassen	L-1	320	E½	17	33N	7E	Mt. D.	N-S	III
	L-2	320	E½	7	33N	8E	"	N-S	III
	L-3	320	N½	23	33N	8E	"	E-W	III
	L-4	320	N½	24	33N	8E	"	E-W	III
	L-5	320	W½	21	32N	8E	"	N-S	III
	L-6	320	N½	2	34N	5E	"	E-W	IV
	L-7	320	W½	9	33N	10E	"	N-S	III
	L-8	320	S½	11	34N	9E	"	E-W	III
	L-9	320	S½	10	33N	9E	"	E-W	III
	I-10	320	E½	28	32N	10E	"	N-S	III
	L-11	320	N½	18	32N	7E	"	E-W	III
	L-12	320	N½	6	32N	6E	"	E-W	III
	L-13	320	S½	23	35N	6E	"	E-W	IV
	L-14	320	N½	16	34N	7E	"	E-W	III
	L-15	320	S½	17	33N	9E	"	E-W	IV
	CO-6	320	S½	35	33N	9E	"	E-W	IV
	CO-7	320	W½	1	32N	8E	"	N-S	III
	CO-8	320	N½	23	32N	9E	"	E-W	IV
	CO-9	320	S½	14	31N	9E	"	E-W	III
	CO-10	320	S½	13	30N	8E	"	E-W	III
Plumas	P-1	320	N½	13	26N	14E	"	E-W	III
	P-2	320	E½ NE¼	11	25N	14E	"	N-S	III
			E½ SE¼	11			"		
			W½ NW¼	12			"		
			W½ SW¼	12			"		
	P-3	320	N½	16	26N	13E	"	E-W	III
	P-4	320	S½ SW¼	31	25N	15E	"	E-W	III
			S½ SE¼	31	25N	15E	"		
			N½ NW¼	6	24N	15E	"		
			N½ NE¼	6	24N	15E	"		
	P-5	320	E½	14	25N	13E	"	N-S	III
	CO-23	320	S½	26	25N	13E	"	E-W	IV
	CO-24	320	S½	17	24N	13E	"	E-W	IV
Stanislaus	SS-1	320	W½	9	4N	15E	"	N-S	III
	SS-2	320	W½	29	1N	18E	"	N-S	III
	SS-3	320	N½	32	1S	19E	"	E-W	III
	SS-4	320	SE¼	27	7N	15E	"	E-W	II
			NE¼	34	7N	15E	"		
	SS-5	160	SW¼	27	4N	18E	"	N-S	II

Nat. Forest	Plot	Acres	Subdiv.	Section	Twnsp.	Range	Meridian	Cruise Dir.	Site
Stanislaus	CO-11.	160	.In part	.30-31 .	4N	. 18E	.Mt. D. .	NE-SW	.II
	CO-12	240	E½ NW¼	28	4N	18E	"		
			NE¼	28	4N	18E	"	N-S	II
	CO-13	160	S½ SW¼	27	5N	15E	"		
			N½ NW¼	34	5N	15E	"	E-W	II
	CO-14	320	In part	17,19,20	4N	18E	"	NE-SW	II
	CO-15	160	NWNW,						
			SWNW	14	1S	19E	"		
			NENE,						
			SENE	15	1S	19E	"	N-S	III
	CO-16	160	NE¼	14	2S	19E	"	E-W	II
Sierra	R.S.7	320	N½	22	8S	23E	"	E-W	III
	R.S 8	320	W½	28	6S	24E	"	N-S	III
	R.S 9	320	S½	10	6S	24E	"	E-W	III
	R.S 10	80	In part	9-10	8S	23E	"	N 23°E	III
	R.S.12	320	E½	7	11S	26E	"	N-S	II
	R.S.13	320	W½	17	10S	25E	"	N-S	III
	CO-17	160	NE¼	34	4S	20E	"	N-S	II
	CO-18	160	SE¼	21	5S	20E	"	N-S	IV
	CO-20	240	E½ NW¼	5	10S	24E	"		
			NE¼	5	10S	24E	"	E-W	IV
	CO-21	160	SE¼	28	5S	21E	"	E-W	II
	CO-22	640		16	9S	25E	"	E-W	II
Mono	Mo-1	320	SW¼	8	2S	27E	"		
			NW¼	17	2S	27E	"	N-S	IV
Inyo	I-1	640	E½	11	3S	27E	"		
			NW¼	12	3S	27E	"	N-S	III
Yosemite Nat. Park	R.S.14	320	NE¼	31					
			NW¼	32	1S	20E	"	E-W	II

CONVENTIONAL SIGNS AND SYMBOLS

Works and Structures

- Canal or ditch
- Water pipe
- Flume
- Main road
- Secondary road
- Trail
- Railroad
- Ranger station
- Building, small scale
- Building, large scale
- Sawmill or millsite
- Campsite
- Telephone line
- Transmission line
- Fence, wire
- Fence, worm (wood)
- Bridge
- Dam
- Corral
- Mine or quarry
- Well

Relief

- Depression, lava crater
- Bluff or cliff
- Rock outcrops

Drainage

- Stream, small
- River, large
- Intermittent stream
- Lake
- Intermittent Lake
- Marsh
- Spring

Boundary Marks and Monuments

- Forest Boundary
- National or State boundary
- County line
- Type boundary
- Section corner, found
- Section corner, doubtful
- Section corner, not found

Tree Species

- Ponderosa pine
- Sugar Pine
- Jeffrey pine
- Lodgepole pine
- Coulter pine

EQUIPMENT

The equipment used by compassmen and spotters on insect surveys is listed as follows:

Compassman	Spotters
USFS compass and staff	Axe, 2½# D.B., marking, or boy's
Map sheets; either blueprints of each plot to be furnished, or the use of Treating Plats. (Treating plats consist of an 8" square ruled off in one-inch subdivisions and are used for mapping on a scale of 16" to one mile.)	Tree record forms
	Timber crayon
	Pencil (2H or 3H) and eraser
	Diameter tape, steel
	Biltmore rule
	Increment borer (when taking cores(
	Core can (when taking cores)
	Indelible pencil (when taking cores)
	Cyanide killing vial (advisable)
	Timber scribe
Tatum holder, aluminum, 9" x 12"	
Timber crayon	
Pencil (3H) and eraser	
Last number used in the preceding cruise of the current infested trees.	

The above equipment will be augmented when making cruises of green timber on sample plots. This will include the following:

Compassman	Spotters
2½-chain steel tape	Spotting records
USFS location markers and galvanized shingle nails (advisable when working on new plots.)	Tatum holder, aluminum, 5" x 8"

In addition each crew should be furnished with information regarding the last serial numbers of previous cruise for each plot, location of each plot, magnetic declination used on each plot, and any special information desired from the current cruise.

FIELD FORMS

The following forms are used in the regional survey:

Tree Record (Control Data) GPO form #8-5223.
Spotting Record. GPO form #8-6852. Form EC-38
Plot maps for each plot (Blueprinted)
Treating Plat
Plot Data - Regional Survey (Mimeographed)
Photographic Record (Mimeographed)
Stem Analysis Record (Mimeographed)

Tree Record

One of these forms is to be completely filled out for each infested tree on the plot or cruise strip. Only one side of the form is used in the survey work, the reverse side (Control Data), being used only on control projects.

Project Area No.....The name of the national forest, park or private holding is noted in this space.

Unit.....List the plot number.

Tree Number.....The tree number includes the abbreviation of the year killed, "S" or "W" to denote what seasonal brood killed the tree, and the serial number of the tree.

Killed By.....The insect species responsible for the death of the tree is noted here. If more than one species were responsible, note the word "MIX" in this space. If the basal examination fails to reveal any of the primary species (see note on page 6) the word "UNKNOWN" is placed in this space.

Year.....Note the year the tree was killed.

Summer or Winter Brood.Check the brood responsible for the original attack upon the tree which resulted in its death.

Location Forty, etc..)These spaces are left blank when cruising
Owner.....)on sample plots

Foliage.....Check the various stages of fading.

Tree Species.....Check the species of the tree. Other species than the ones listed (yellow and sugar pines) will have to be noted and checked in this space.

CONTROL DATA

Date of felling _____ Date of treating _____

Infested length _____ Dia. at base _____ Dia. at top _____

Method of Treatment:

TREE	BRUSH	LOG	BARK	INSECTS
Left stand	Left on	Laid flat	Left on	Burned
Felled	Trimmed	Off ground	Peeled ¼	Suncured
	Piled	Rolled	" ½	
	Spread		" all	

Size of Crew _____ Treating time _____ man, mins.

Remarks:

Crew Foreman _____

GOVERNMENT PRINTING OFFICE 8—5223

Project area No. ---------- Unit ---------- Tree No. ----------

Killed by ----------

Year ---------- { Summer brood ---------- / Winter brood ----------

Location ----------

Forty ------- Sec. ------- T. ------- R. -------

Owner ----------

	D. BREV.	D. MONT.	IPS.	
Attack				
Parent adult				
Eggs				
Larvæ 0 to .5				
Larvæ .5 to 1				
Pupæ				
New adults				
Emerging				
Abandoned				
Infested length				

FOLIAGE
- Green
- Fading
- Sorrel
- Red
- Black

Yellow pine
Sugar pine

D. B. H.
No. 16-ft. logs
B. F.

Remarks:

8—5223

Date ---------- Camp No. ----------

Spotter ----------

D.B.H.....Diameter of the tree (breast high) to the nearest even inch.

Number of 16-ft.Logs.Note the number of logs in the tree up to an 8" top diameter (*).

B.F.....The board-foot volume is computed in the office from volume tables.

Remarks.....Include any pertinent data concerning the tree, such as fire scars, lightning injury, abundance of predators present, etc. The tree class is always noted in this space.

Date.....Date of the cruise.

Camp No.....Left blank.

Spotter.....Surname or initials of the spotter.

(*) Broken-topped trees should be recorded as a fraction, the numerator representing the number of logs actually in the tree and the denominator the total number of logs which would have appeared in the normal tree had there been no break. Thus, 5/7 would be a tree whose height would normally have been seven logs, but because of the break, only the lower five logs remain. The volume of this tree is computed by deducting from the volume of the normal seven-log tree the volume of the two logs lost in the break. The diameter of the top end of these two logs must be estimated and their volume determined from the Scribner log rule.

A forked tree should be measured and recorded as one tree, if the fork is high enough to permit the cutting of one butt log 12 feet or more in length. Otherwise, each fork should be measured and recorded as a separate tree. (From Timber Survey Manual, U.S. Forest Service, Region 5, 1924.)

Spotting Record

The spotting record is used only on cruises of green timber. The form is used by the spotters to record the information obtained from each green tree on the strip. The heading is filled out to include the national forest or park name, number of the plot, date of cruise, and the spotter's name. The column headings will be changed as follows:

Tree Number (Column #1) Each green tree tallied will be numbered in consecutive order on each plot. This number will be used to designate the core taken from each tree.

Tree Class (Column #2). This column is changed to record the tree class of each of the green trees tallied. Use Keen's tree class.

D.B.H. (Column #3)..... Record the breast high diameter to the nearest even inch.

Logs (Column #4)..... Record the number of 16-foot logs up to an 8" top diameter. (See note above.)

Volume (Column #5)..... The board-foot volume of each tree is recorded in this column. This is done in the office, using the proper volume table and corresponding site index.

Tree Species (Column #6.).This column will be used to denote the tree species.

Remarks (Column #9).....This column will be used to note each five-chain section of the strip. This will group the green trees tallied into sixteen half-acre units for each mile of strip run. This will be recorded as 0 - 5, 5 - 10, etc.

Each spotting record used on the green cruise must bear the number of the strip. Strips upon which the green cruise are run are usually located parallel to the longitudinal axis of the plot and at 1, 3, 5, and 7 tallies from one of the longitudinal boundaries.

Blueprint Maps

Tracings have been made from the original maps for each plot, showing culture, topographic features, drainage, timber type, etc. on a scale of 16 inches to the mile. Blue-line prints will be furnished the survey crews in the future making the use of the treating plats unnecessary except when mapping new plots or cruise strips.

Treating Plats

The treating plats, one of which is shown, are used by the compassmen for the purpose of mapping in such features as culture, topographic detail, drainage, and timber types on newly established plots. The scale used on such maps is 16" to the mile and on a 320-acre plot, two treating plats will be necessary. Each treating plat should be labelled as to the name of the national forest or park, plot number, exact location of the plot, location of land subdivision corners, magnetic declination used, and any other essential information obtained. The mapper should use the accepted symbols for features and types shown elsewhere in the Appendix.

Plot Data - Regional Survey Form

This form is used by the compassman when laying out new sample plots and is usually filled out after the stand cruise is made. It can then be checked while the insect loss cruise is being made.

Survey No.....Year in which the plot was established.

Plot No.....The number of the plot will depend upon which of the three series it belongs. This has been described in detail under "Location of Sample Plots" in the Appendix.

Forest.....Name of the national forest (or Park) upon which the plot is located.

T.__R.__S.__'.__.....The township, range, section, and meridian is shown.

SPOTTING RECORD

Project area_____ Unit_____ Camp No._____

Date_____ Spotter_____ T.____ R.____ Sec.____

Tree No.	Killed by	D B H	Logs	Volume				Remarks
Totals,								

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TREATING PLAT

*Project Area*_____ *Unit*_____ *Camp No.*_____

*Date*_____ *Compass man*_____ *T.*_____ *R.*_____ *Sec.*_____

*Remarks:*_____

PLOT DATA---REGIONAL SURVEY

Survey No._____ Plot No._____ _____Forest

T.___R.___S,___M.___ Alt._____For.Type_____

Area_____ Cruise Dir._____ Compass Dev. _____

Corners _____

_____

_____

_____

Stand Cruise Lines_____Cr. Cor._____ % Cr._____

TOPOGRAPHY: Slope Grad._____ Slope Exp._____

Features _____

_____

_____

_____

_____

_____

_____

Stand, Area_____ Site Class_____ Cond.Man._____

Species_____

Pred. Classes_____ Thrift_____

Density_____ Fire Inj._____

Repro._____ Ground Cover_____

Gr. Cov. Sp._____

SOIL: Source_____Depth_____

Character_____

Drainage_____

Weather Station_____Pertinence_____

Remarks_____

Alt.....Note approximate altitude of the plot.
For. Type.....The forest type is designated by means of the standard types used by the Forest Service and described elsewhere in the Appendix.
Compass Dev.....The magnetic declination of the compass needle must be noted.
Corners.....All section corners falling on the plot boundaries or within the plot are to be noted. This includes quarter- or sixteenth-corners which may be found. Here also should be an accurate description of the location of the plot.
Stand Cruise Lines..Location of the lines upon which the stand cruise was made.
Cr. Cor.....Cruise correction factor. This is obtained by dividing the total timbered acreage on the plot by the total timbered acreage on the strips.
Percent Cr.....This is usually the figure obtained by dividing the total area of the strips by the total area of the plot.
Topography: Slope Grad..The approximate slope gradient is expressed as level, gentle, medium, steep.
Topography: Slope Exp.Slope exposure. What cardinal direction does the slope face?
Features.....Describe the general features of the plot such as improvements, accessibility, occurrence of lava flows, large streams, etc.
Stand, Area.....Timbered acreage on the plot. This is usually determined in the office.
Site Class.....Determined as described under "Site Index" in the Appendix.
Cond. Man.....Condition of management, whether logged or virgin stand, turpentine operations, etc.
Species.....The timber species present on the plot.
Pred. Classes.....The predominating classes based upon Keen's tree classes.
Thrift.....General statement of thrift of stand.
Density.....General statement of the percent of stocking based upon density of crown canopy.
Fire Inj.....Description of injury to stand from ground or other types of fires.
Repro.....General statement of the reproduction conditions on the plot, whether good, medium, poor or lacking.
Ground cover.....Whether herbaceous, shrubby, or reproduction.
Gr. Cov. Sp.....List the species making up the ground cover.
Soil: Source.....Whether volcanic, granite, alluvial, etc.
Soil: Depth.....Medium, shallow, or deep.
Character (of Soil).Loose, hard, eroded, etc.
Drainage.....Poor, fair, good.

Weather Station.....Location of nearest station.
Pertinence.....Whether indicative of conditions on the plot or irrelevant due to change in altitude, precipitation belt, or temperature belt.
Remarks.....Note any remarks of general interest not covered by the above items.

Photograph Record

This form is used to record the data from a series of "repeat" photographs taken of a subject over a long period and under identical conditions. The pertinent information regarding the initial photograph must be accurately recorded in order thatsubsequent photographs of the same object may be taken under similar conditions for purposes of comparison.

Photo No.....This number is an assigned number and part of a series given to each of the personnel from the series allocated to the forest insect field station at Berkeley.
Plot No.....Give the plot number.
Date.....Date of initial photo.
Forest.....Name of the forest (or park).
T.__R.__S.__;__M.__...Township, range, section and meridian.
Location of Base Point.Describe briefly but accurately the exact location of the base point, or camera set-up. This point must be tied in to some prominent and permanent point, such as a corner of the plot, section corner, bridge-head, etc.
Ht. of Camera.....The height of the camera should be noted.
Direction of Lens.....The compass bearing of the direction toward which the lens face is noted.
Time of Day.....Given to the nearest half-hour.
Sky Cond.....The sky condition is given; whether clear, partly cloudy, overcast and light, overcast and dull.
Focal Lgth.....The focal length of the lens of the camera making the initial photo is given.
Stop.....The stop number, or "f" number is noted.
Exposure.....Exposure time in seconds.
Filter.....Note the filter number and make of filter.
Subject:.....Briefly describe the subject to be photographed so that it may be readily found in repeat photographs.
Object of Series.....The object of the series of photographs should be given, such as noting the progress of topkilling on a tree, or the progress of group killing and deterioration of snags.

Repeat Photographs.....The number, date, photographer, and remarks concerning subsequent photographs. The latter should include any changes made in the set-up, stop number, time of day, sky conditions, film, etc. These items should never be changed from those used in the initial photograph unless absolutely necessary.

Stem Analysis Record

Closely associated with the regional survey is the stem analysis of infested trees. This comprises a detailed investigation of the entire length of bole of infested trees which is used in determining:

1. Point of attack, direction and rate of spread of attacks for the major barkbeetle species.

2. The species initiating attacks on green trees, if possible.

3. The bark surface infested by each or several species together

4. The various combination of attacks as regards insects involved, location on bole, and relative importance as to area covered.

Analyses are made by sampling infested trees felled especially for that purpose, or those felled during control or logging operations. Data is recorded on a special form, the Stem Analysis Record, which is shown.

Procedure: The bole will be divided, up to a 4" top whenever possible, into green, infested, or abandoned lengths. Green areas are those free of insect attack; infested lengths include the presence of insect stages of a single species or several in mixture; abandoned lengths are those in which insect broods of one or more species have developed and emerged fairly recent. Another designation, "stag-top", is used to denote those old dead tops caused by lightning, insects, fire, disease, or mechanical injury. The infested and abandoned lengths of the bole will be broken down into smaller sections each of which is uniform as to the species of insects present and also the various developmental stages of those insects present. In addition, these small homogeneous sections will be further divided at points of forking in the main bole, at sawkerfs resulting from bucking, and at breaks. This latter division will apply to green sections as well as infested and abandoned. Each section analyzed on the bole is to be designated "A", "B", "C", etc., beginning with the

butt. The following information is essential for each section:

1. Average diameter (to the nearest inch) at both ends, outside of bark.

2. Length (to the nearest foot)

3. Infestation condition.

4. Such information as is considered necessary such as section salvaged, left in woods, treated, untreated, etc.

A rough sketch of the bole is to be prepared on the Stem Analysis Record in the space provided and showing the form of the bole (whether single or forked), and the approximate location and designation of each section.

The analyst should include each of the following major bark beetle species on the form whenever they occur in significant amounts:

DM, DB, FH, DJ, IE, IO, and IC (See abbreviations, page 6).

Very scattered or occasional attacks definitely having no effect on the infestation should be omitted. A knowledge of the relative importance of each species as a primary insect should aid in determining the point at which the occurrance of any species ceases to be significant. Studies recently completed by the Bureau show that several of the so-called "primary" species listed above occur as fill-in attacks following original attacks of other species.

Under "Remarks" on the Stem Analysis Record, the analyst should endeavor to designate, if possible, the approximate proportion of each species making up a mixed infestation, the primary species originating the attack, and the point and direction of attack. The infested sections of the bole will be either pure or mixed broods, i.e., one species or more than one. For each insect recorded, list the species, stages, year and generation (1934S, 1935W, etc.).

It should be remembered that some of the general information called for on the form (foliage phases and tree class) must be secured before the tree is felled and the analyst should plan his work accordingly.

Bark surface area can be computed with any of the following formulas:

$$S = (\pi)(r_1 + r_2)(h)$$

where S = bark surface in square feet
π = 3.1416
r_1 = radius at one end of section (in feet)
r_2 = radius at other end of section (in feet)
h = length of section (in feet)

$$S = \frac{(\pi)(h)(d_1 + d_2)}{24}$$

S = bark surface in square feet
π = 3.1416
d_1 = diameter at one end of section (in inches)
d_2 = diameter at other end of section (in inches)
h = length of section (in feet)

$$S = \frac{(h)(c_1 + c_2)}{2}$$

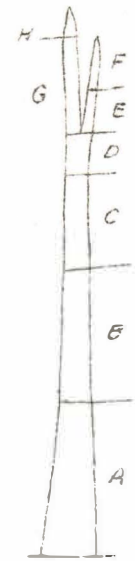
S = bark surface in square feet
c_1 = circumference at one end of section (in feet)
c_2 = circumference at other end of section (in feet)
h = length of section (in feet)

STEM ANALYSIS RECORD

Felled 5/20/35 Green ____ Red ✓ Top Killed by D.B. Tree Spp. PP Tree No. 34W-2
Examined 5/20/35 Fading ____ Black ____ Year 1934 D. B. H. 36" Plot No. MC-10
Examiner L.D.W. Sorrel ✓ ____ Generation W 16' Logs 5 Nat. For. Modoc
Class: Keen 3C Dunning 4 B.M. Vol. 1640

Sec. No.	Dia. Base	Dia. Top	Ht.	Bark Area	Insects Remarks
A	38"	32"	14'		DB 1934W - L(0-½)(½-1)
B	32	27	25'		DB 1934W - L(½-1) DM 1934W - L(½-1), pupae
C	27	18	36		DB 1934W - L(½-1), few pupae DM 1934W - L(½-1), pupae, N.A. FH 1934W - L(½-1)
D	18	14	14		Same as "C" above
E	14	10	12		Same
F	10	4	9		FH 1934 - L(½-1)
G	15	12	15		Same as "F" above
H	12	5	20		FH aband. Probably 1933 brood

Sketch



INTRODUCTION

The methods of determining the amount and character of insect losses in the California pine regions have been in general use for a number of years. These methods of determining insect conditions in the forest are usually known as Insect Control Surveys. Their purpose is often two-fold:

1. To determine the amount, intensity and trend of barkbeetle infestations as a basis for recommendations regarding necessity and cost of control measures, and

2. To obtain pertinent data to be used in research phases of forest insect investigations.

These surveys are conducted in a more or less systematic manner and make use of both extensive and intensive methods. The former is carried out by means of topographic reconnaissance, strips, or observation; the latter by sample plots, and strips. In order to improve the quality and ease of sampling in the various field activities, it has been necessary to standardize the methods used. The seasonal character of the survey often accounts for frequent turnover in field personnel and the training and supervision of new men can be facilitated under such a plan. The field methods to be described below are compiled from the standardized field methods of the U. S. Bureau of Entomology and Plant Quarantine and the U. S. Forest Service.

TYPES OF SURVEYS

Extensive Surveys

Extensive surveys of forest insect conditions are carried on under conditions which require the sampling of the largest area in the minimum of time and with the least expense. The accuracy of such surveys naturally depends upon the objective and upon the experience and judgment of the personnel. This type of survey makes use of the following methods, all of which are merely indicative:

1. Topographic
2. Strip counts
3. General observations

"Topographic spotting" is used in rough topography where drainage basins, hillsides, or bottomlands can be observed from points of advantage. Insect losses can be roughly determined on a tree basis by counting the number of faded trees in a certain area from a point overlooking the area. Field glasses are usually used to determine

tree species and to distinguish between several years' losses. It is preferable to locate each tree on a topographic map in order to get a better picture of conditions for later reference and to ascertain the number of acres covered. Maps for this purpose are usually enlarged photostat copies of U. S. Geological Survey quadrangle sheets. Only the area to be covered need be used in this case.

Strip counts are used to determine the number of infested trees on a strip which traverses any area to be sampled. The strips are usually five or ten chains wide and may follow roads, trails, streams, compass or section lines. In any case the width and length of the strip must be known in order to determine the percent of the total area sampled. One or two men are sufficient; one man doing the tallying and distance and directional measurements, or on a two-man crew, one man tallying and the other doing the compass and pacing work or driving the car. Trees are usually only tallied by species and year of attack.

General observations of insect conditions in areas of lesser importance can often be ascertained by one man whose familiarity with that particular area and knowledge of conditions in general is sufficient to base his estimates. This method of extensive surveys can only be used when the results are to be used for general information of the trend and relative abundance of the infestation and when the experience of the estimator is sufficient to assure a fair degree of accuracy.

Intensive Surveys

An intensive survey makes use of permanent or semi-permanent samples chosen as being representative of certain larger units. The samples used in forest insect surveys of this nature include plots and "cruise strips", (the latter are not to be confused with strip counts described above). Plots and cruise strips are located with reference to the General Land Office subdivision, but the latter are sometimes located with reference to some physical feature. In any case the width, distance and bearing of the strip must be accurately recorded to facilitate subsequent cruises made on the strip. Spotting procedure, practice, and the compassman's duties on cruise strips are the same as those required for plots and will be described in detail below.

The plots used by the regional survey are usually 320 acres in extent and are representative of certain larger units, which in turn have been defined by natural barriers, timber type, economic units, etc. Plots now in use are of three types: (1) "regional survey" plots which have their boundaries and intermediate cruise lines brushed out and permanently marked with metal tags, (2) ordinary "survey" plots which are cruised each year by compass-and-

pacing control, and (3) "cutover" plots which are cruised similar to the survey plots described in (2) above. The first two types are usually located in virgin stands, the latter in cutover stands as the name implies.

INTENSIVE SURVEY METHODS

Organization of Field Crews.

The field party for the regional survey is composed of two or more men. A two-man crew can be used on regional survey plots and occasionally on cruise strips, because the presence of metal tags at 2½-chain intervals and the brushed-out lines on this type of plot makes the use of a compass and pacing unnecessary. In this case one man maps, the other covers a five-chain strip as a spotter.

The three-man crew is perhaps the most efficient under all conditions. This provides a compassman and two spotters. Where the chief of party has other duties which force him to be absent from the survey crew at frequent intervals, or when infestations are heavy, provision should be made for an extra man. This allows a minimum of three men at any one time. The equipment used by the survey crews is listed in the Appendix.

Procedure.

The procedure of the field survey work must be uniform from year to year if the best results are to be obtained for purposes of comparison as well as accuracy.

The compassman must use the greatest care in maintaining true lines, checking in at all section and quarter-section corners through which the plot boundaries pass. It will also be necessary for him to check the spotters as they near the boundary of the plot or strip in order that they do not mark trees outside the boundary.

The map will be on a scale of 16" to the mile. Plans have been made to have blueprinted maps for each plot in the Region showing all essential information and features. This will cut the time of the compassman in mapping physical features and makes necessary only the locating of the infested trees on the map. When necessary to map or make additions to existing maps, the Forest Service map symbols shown in the Appendix should be adhered to.

The compassman will control the list of serial numbers used for marking infested trees and give them in consecutive order as they are required by the spotters, being careful not to duplicate or skip any numbers in the same series. There shall be one series of

numbers, beginning with "one", for each year's losses regardless of tree species or insect species, summer or winter broods. When picking up the previous year's losses, part of which are already marked in a previous cruise, continue the number series where that cruise left off. Serial numbers, as used on both infested trees and the map, are in the form of a fraction. The numerator denotes the abbreviation of the year ('33 for 1933, etc.) and the letter "S" or "W" to denote which brood (summer or winter) killed the tree. The denominator consists of the number of the tree in that particular series. Thus 33S/15 will be used on the map to denote that the tree was killed by the summer brood (if more than one seasonal brood occurs) of 1933 and was the fifteenth tree killed on the plot during the season of 1933. The symbol " ▲ " placed to the left is used only on the map to denote the tree species, Jeffrey pine in this case.

The term "spotting" as used in barkbeetle surveys, involves the examination of all trees in a given area for the purpose of locating those trees which are infested by barkbeetle broods, or which have recently been attacked and are now abandoned. The spotting work is done by spotters who must possess certain requirements such as ability to distinguish colors, particularly various stages of fading foliage, a certain knowledge of barkbeetles and associated forest insects including their habits, life history, and character of work, and the ability and willingness to do careful work.

The strip system of cruising is used on all sample plots, the width of strip varying from five to ten chains in width. This strip is further divided so that each spotter has in reality a strip of his own and equal to that of the other spotters. Each spotter must then locate, examine, and mark each infested tree on his own strip. As soon as he is convinced that a tree is to be marked as infested, the compassman must be notified as to the year in which the tree was attacked. He will respond with the serial number which will be placed on a sapwood blaze on the north side of the tree in the manner explained in the preceding paragraph. Actual spotting practive will be described in detail below.

In order to maintain the accuracy and speed with which the cruise is carried on there must be complete cooperation between spotters and compassman. The spotters should respond to each tally number called out by the compassman as this is the only means of keeping together in rough or extremely brushy country. Spotters should never be more than one tally ahead of or to the rear of the compassman and vice versa.

It is essential that all data asked for be completely filled out

on the forms while at each tree. Data left for subsequent completion is too often never finished and a lack of, or incorrect, data results.

Checks on accuracy should be made by the compassman and spotters as the season progresses. Compassmen should check their pacing occasionally, and the compass should be inspected for loose screws, bent needle, loose or incorrect declination adjustments, etc. Spotters should check D.B.H. and log-height estimations, the former by diameter tape and the latter by hypsometer. Constant vigilance is necessary to note seasonal development of insect broods, and ascertain periods of new attacks. Practice in pacing will also help the spotters to determine the edge of their strip and to check ocular estimates of such distances.

Spotting Practice.

The standardization of spotting practice on the regional survey needs to be emphasized more than any other part of the work. At the best, much of the spotting work depends upon the judgment of the spotter. Certain requirements, however, will help the spotter in exercising his judgment.

The primary function of the spotter is "spotting", i.e. he is responsible for detection of infested trees. These are noted by certain external indications of infestation; namely, fading or faded foliage, fresh or recent pitch-tubes on the bole of the tree, sawdust (frass) in bark crevices and on ground at the base of the tree, woodpecker work, either scaling or individual holes, in the bark of the bole, and exudations of pitch which form long stringy accumulations on the bark of the bole of Jeffrey, sugar and lodgepole pines. When any or several of the above indications are present, an examination of the bark and cambium layer by chopping with an axe usually discloses the presence of insect broods, but not always. In trees where external signs of attack are vague, care should be used not to injure the cambium and not to leave the cambium exposed, if possible.

The various types of infested trees marked on the regional survey in the past has shown much freedom of interpretation by the spotters. There are four distinct types of infested trees to be marked, as regards basal examination and consideration of external indications of attack. These are listed:

(1) Trees in which attacks or brood of any, or several, of the so-called primary species* can be found in the basal examination. The entire foliage is fading or faded.

*The primary species of barkbeetles recognized in California include the following:

D.B. (Dendroctonus brevicomis Lec.) in ponderosa and Coulter pines.
D.M. (Dendroctonus monticolae Hopk.) in ponderosa, sugar and lodgepole pines.
D.J. (Dendroctonus jeffreyi Hopk.) in Jeffrey pine.
F.H. (Melanophila californica Van D.) in ponderosa, sugar, Jeffrey and Coulter pines.
(Melanophila gentilis Lec.) in ponderosa, sugar, Coulter and Jeffrey pines.
I. E. (Ips emarginatus Lec.) in ponderosa, sugar, lodgepole, Coulter and Jeffrey pines.
I.O. (Ips oregoni Eichh.) in ponderosa, Jeffrey, and lodgepole pines.
I.C. Ips confusus Lec.) in ponderosa, Coulter, sugar, and lodgepole pines.
MIX Includes any mixture of two or more of the above species.
UNKN Unknown. This designation should be used where evidence of any of the above species is lacking in the basal examination. Trees with attacks of Dendroctonus valens Lec. in the base and with none of the above species present are included in this classification.

The spotter should endeavor to determine those species responsible for the death of the tree from the evidence appearing in the base of the tree, or as much of the bole as can be reached from the ground. Such species, whether one or more, should be noted in the proper space (Killed By .....) in the tree record. All stages of primary insects found in the base should be checked on the record.

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(2) Trees with no indication of insect attack in the base but with the entire foliage fading or faded. No indications of mechanical damage to the tree are apparent.

(3) Trees with no indications of insect attack in the base, but with top foliage fading, and fresh pitch tubes or frass on the middle portion of the bole.

(4) Trees with all insect stages abandoned in the base and with the entire foliage red (not sorrel). These trees were attacked and abandoned by broods of the current year or preceding year.

In addition to the above four types of infested trees, is a fifth, the "topkilled" tree. Topkilled trees are those in which an active and considerable infestation occurs in the top of the tree, the remainder being green. They can be recognized by the spotter because of the significant fading of the top foliage. The foliage below this fading remains green. The fading of an occasional branch of the tree is not considered as sufficient proof of topkilling.

The regional survey will include the determination of topkilling activities on certain representative plots. Topkilled trees will be marked on those plots in conjunction with insect loss cruises. The spotter will mark and complete a tree record for each topkilled tree on the plot and the mapper will locate its position and number on the map. Topkilled numbers will be in fractional form, i. e., $\frac{TK33}{101.}$ The numerator includes the abbreviation "TK" and the year in which the initial topkilling attack occurred. The denominator bears the serial number which will be of the same series as used to mark infested trees attacked in the same year.

The number will be placed on the north side of the tree with a timber scribe after the bark has been smoothed off down to the inner bark, care being taken not to injure or expose the cambium. The scribing should be deep and carefully done to insure legibility for several years.

Data to be recorded for each topkilled tree will consist of the number (do not omit the "TK"), the year of the initial topkill attack, D.B.H., height in logs, tree class (Keen's) foliage phases and relative percent of fading, date of examination, name of spotter, and general remarks concerning injuries due to fires, lightning, etc.

The regional survey is primarily for the purpose of determining barkbeetle losses. However, in addition to these, other types of insect losses including defoliation, bud and twig losses, and reproduction damage by insects should be noted whenever possible by members of the survey crews.

ESTABLISHMENT OF NEW PLOTS.

Plots will be selected by a reconnaissance survey previous to or in conjunction with a regional survey. The reconnaissance will determine the location and general characteristics of areas intended for use as sample plots. This may or may not involve the use of the survey crew. Such work and the final selection of the plot or plots is usually done by general observation based upon experience and ability to locate areas for sampling. Insect survey plots are 320 acres or one-half section in area whenever timber type and topography permit. In uniform timber types and level topography such as the eastside type plots in northeastern California, regularly established land office subdivisions form the plot boundaries. In the westside Sierra region, rough topography and frequent change in timber types sometimes determines the direction of the axis of the plot, cruise lines and boundaries. Where plot boundaries are not coincident with land office subdivisions, plot corners should be tied in to section or quarter-section corners by compass and chaining.

Initial Survey.

Two surveys are made on all new plots; the first, or initial survey, to establish and mark corners and boundaries, to determine lines of cruise and mark them, to map the plot, to obtain a stand estimate, and to obtain general plot data; the second cruise, to determine insect losses, has been described above. A three-man crew on the initial survey is madd up of compassman, mapper, and estimator. In heavily stocked stands the estimator may be given aid from either of the other two. All distances are measured horizontally; bearings are made with staff compass (Forest Service) corrected for magnetic declination.

Plot corners should be marked by a stout post or stake, smoothed on four sides, with plot number, plot corner, and U.S.B.E. & P.Q. marked clearly with timber cravon. Where plot corners coincide with General Land Office corners, Forest Service, or county surveyor's corners, care must be taken not to disturb these. If U.S.F.S. cruise tags are lacking, it is well to place one or two on different witness trees facing the corner, only after the corner has been definitely identified.

When plot boundaries, cruise lines, or traverses follow section lines tree blazing should be restricted to a minimum. Light bark blazes may be occasionally used but should be restricted to the distinctive form used by the Forest Service; three light notches, one above the other, in the bark or a slight cut about two feet from the ground instead of breast-high. Do not use env marks which expose the cambium or sapwood of green trees. When a section line crosses a road or trail it is well to place a Forest Service cruiser's tag on the nearest tree, facing the section line, if possible, but visible from the road or trail. The location at that point is marked by a tack driven through the tag into the bark and the distance to the nearest corner scratched on the tag.

Regional survey plots are marked with metal boundary tags every five chains and intermediate cruise lines every 2½ chains, the latter with tags upon which are marked the coordinate distances from the southwest corner of the plot. The placing of the tags is shown in the Appendix. The boundary and intermediate lines are chained, brushed out. Occasional maintenance is necessary to replace tags and brush lines. The use of these tags makes it possible for two men to carry on subsequent insect surveys, and also increases the speed of the survey when three-men crews are used by doing away with the need of compass alignment.

A map will be made by the compassman or mapper for each plot on a scale of 16 inches to the mile, on ordinary treating plat forms. Using standard Forest Service symbols (see Appendix), the map will

show topographic features, culture, timber type, drainage, etc. Timber types will be those now in use by the California Forest and Range Experiment Station. These are shown in the Appendix.

In addition to the map, the compassman or mapper will fill out the "Plot Data-Regional Survey" form. The form and descriptions of the terms used are shown in the Appendix.

The estimator will tally all green coniferous trees on ten percent of the plot area. The strip method is used, each strip being one chain (66 feet) wide and the length equal to longitudinal length of the plot. On a standard plot covering one-half section, four strips ten chains apart, parallel to the longitudinal axis, and 80 chains long would result in a ten percent estimate of the total stand on the plot. The estimator tallies all green trees above 6" D.B.H. on the strip, 33 feet on each side of the compassman. Trees with centers exactly 33 feet from compass line are omitted. For each tree will be recorded the plot number, species, DBH, height in logs (to 8" top), tree class (Keen's.)

An increment core will be taken from the north side at breast-height and the plot number, species, DBH, and tree class will be recorded on the core in indelible pencil.

Stand cruise data will be taken on the Spotting Record form shown in the Appendix. The second column will be changed to read "Species" and the sixth or seventh will be used to designate tree class. The data should be grouped for every tally or five chains of strip run and labelled; i.e., line 3 east, 5-10 (chains) north, etc. This will break the data into half-acre units for purposes of comparison and distribution.

Insect Loss Survey.

The second cruise in the establishment of new plots is the determination of losses. Losses will be divided into two groups: current and past losses. The former includes losses of the present and previous year and are obtained as described under Insect Survey Methods above. Past losses, because of the obliteration of infestation information due to decomposition of the dead trees, will be recorded as snags; tallied by DBH, height in logs and species, and located on a special snag map on a scale of 16" to the mile. Increment cores will be taken from all current infested trees during this cruise and for subsequent insect loss cruises for the first few years following the establishment of new plots. Cores should be clearly marked with indelible pencil as to plot number, tree number, DBH, and tree species.

CUTOVER PLOTS.

Sample plots in cutover forest lands have, for their objective the following:

1. Determination of importance of losses caused by insects in reserve and second-growth.

2. The study of the following relationships:
   (a) loss and increment.
   (b) loss and site index.
   (c) loss and timber type.
   (d) loss and methods of cutting.
   (e) loss and diameter distribution.

3. The determination of the status of infestations in pole stands and reproduction on cutover areas.

Plot Selection.

Plots are to be 320 acres unless unwarranted or impossible due to ownership, timber type, difference in marking practice, methods of logging, or environmental factors. An isolation strip with like conditions should surround the plot whenever possible.

Establishment of Plots.

The methods and procedure are similar to those mentioned under Establishments of New Plots (above), with certain variations. The stand cruise includes a 10 percent estimate of the reserve stand (over 11.5 inches DBH), obtaining measured DBH, estimated number of logs, tree class (Dunning's), and tree species for each tree on the strip. All poles (3.5 to 11.5 inches DBH.) are tallied by DBH., and species only.

Reproduction study plots* are placed at ten-chain intervals along the strips used in tallying the green stand. These subplots are one-half chain in width and two chains long; the length being chained, width estimated. The following procedure is taken from the Forest Management Handbook, Region 5, U.S. Forest Service (1928):

"The stocking of reproduction will be shown graphically ..... as follows: Each plot is ruled off five inches in length by one and one quarter inches in width. This ruled space contains 100 one-quarter inch squares, which correspond with 6.6-foot squares on the ground. The estimator enters a symbol in each square which is occupied by reproduction or a large tree, noting the dominant tree

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* Location of reproduction plots are to be shown on the map and marked on the ground by stake on the compass line.

according to the following legend:

P Ponderosa pine less than 6 feet in height.
Ⓟ Ponderosa pine over 6 feet in height and less than 3.5" DBH.
✓ Any square which contains, or is directly under the crown of a tree larger than 3.5" DBH, regardless of whether or not the square contains reproduction."

Tree symbols for reproduction plots are shown as follows:

P Ponderosa pine
S Sugar pine
J Jeffrey pine
L Lodgepole pine
F White fir
R Red fir
O Oak

Increment cores will be taken from the north side, breast-height, of all infested pine trees, and marked in indelible pencil with plot number, DBH, and tree class (Keen's). About 150 cores will be taken from the green pine reserve. These will be distributed in the proportion of the tree and diameter classes of each of the pine species in the reserve. Since this distribution can only be ascertained following the initial or stand cruise, the green cores will be secured during the second, or insect loss, cruise. Cores from green reserve trees are marked in indelible pencil with plot number, species, tree and diameter class.

In addition, from 25 to 50 increment cores will be taken from the dominant and co-dominant poles and marked with plot number and DBH.

The insect loss cruise is the second of the two cruises made during establishment of cutover plots. Procedure is the same as described under Insect Survey Methods above except that losses in the pole stand are recorded on Spotting Records by tree species, insect species, and DBH. Pole loss is limited to that of the current and previous year as are losses in the reserve stand.

Listed as snags are those trees, 12" DBH., and over, killed two years or more prior to the establishment of a plot. Death may be due in most cases to insect attacks, windthrow, lightning, fire, or mechanical injury sustained by logging, road-building, etc. Snags are listed on Spotting Records by species, DBH. and number of logs.

ANALYSIS OF BARK SURFACE INFESTATION

Closely associated with the regional survey is the stem analysis of infested trees. This comprises a detailed investigation of the entire length of bole of infested trees which is used in determining:

1. Point of attack, direction and rate of spread of attacks for the major barkbeetle species.

2. The species initiating attacks on green trees, if possible.

3. The bark surface infested by each or several species together.

4. The various combination of attacks as regards insects involved, location on bole, relative importance as to area covered.

Analyses are made by sampling infested trees felled especially for that purpose, or those felled during control or logging operations. Data is recorded on a special form, the Stem Analysis Record shown in the Appendix.

Procedure.

The bole will be divided, up to a 4" top whenever possible, into green, infested, or abandoned lengths. Green areas are those areas free of insect attack; infested lengths include the presence of insect stages of one species or several species in mixture; abandoned lengths are those in which insect broods of one or more species have developed and emerged; also included old stag-tops caused by lightning, fire, disease or mechanical injury. The infested and abandoned lengths of the bole will be broken down into smaller sections each of which is uniform as to the species of insects present and also the various developmental stages of those species present. The basal (stump) diameter, diameter at the top end of each section, and the length of each section in feet are measured and recorded. Each section is indicated on the form in graphic method, the measurements and designation of each section being clearly shown.

The analyst should not include every insect species on the form only because it occurs on the bole, or stem. He should determine from observations, if possible, what species were actually concerned with the death of the tree and record only the presence, location, and stages of those species. The mere presence of a primary barkbeetle species does not necessarily mean that that species was actually responsible, in whole or in part, for the death of that tree. Studies recently completed show that many of the primary species occur as "fill-in" attacks following attacks by other species. Such fill-in species would be noted as such whenever possible.